THE UNIVERSITY OF ALBERTA

PROPOSITIONAL VARIABLES IN SYLLOGISTIC REASONING

by

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE

DEPARTMENT OF PSYCHOLOGY

EDMONTON, ALBERTA

FALL, 1972

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "Propositional Variables in Syllogistic Reasoning" submitted by Richard R. Clopper, Jr., in partial fulfilment of the requirements for the degree of Master of Science.

ABSTRACT

The predictive importance of the propositional variables of quantification and qualification in syllogistic reasoning was investigated by analyzing S's validity judgments of conclusions for 64 syllogisms. The Ss were 78 introductory psychology students who had had no previous training in logic. The Ss were randomly assigned to three groups and asked to judge the validity of the syllogistic conclusions on one of three independently randomized lists of syllogisms. Each list contained one fourth figure instance of each of the 64 syllogistic moods. A binary scaling of the quantitative and qualitative characteristics of each syllogistic proposition was used to analyze S's acceptance rates using standard multiple regression and analysis of variance routines. The results indicated S preferences for accepting as valid particular, as opposed to universal, and negative, as opposed to affirmative, syllogistic conclusions. Evidence was also obtained for quantitative and to a lesser extent, qualitative "atmosphere" responding. Significant interactions between the quantitative and qualitative

propositional variables were observed. However, interpretive difficulties arising from the analyses precluded definitive documentation of these effects. Directions for further research are also indicated.

ACKNOWLEDGEMENTS

I would like to thank my supervisory committee, particularly Dr. Rozeboom, for their critical comments and guidance with this project.

Special thanks go to my wife, Terry, for her understanding and support and to Katherine Rollo-Black for her unselfish help with the preparation of the manuscript.

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INTRODUCTION

To date, the experimental literature concerned with syllogistic reasoning has confined itself to two differing aspects of the question, "What are the reasons for syllogistic reasoning errors?" The first of these concerns may be characterized as the effect of "meaning variations" in the subject and predicate terms of the propositions comprising a syllogism. In these studies the exact nature of "meaning variations" has fluctuated markedly, but it is apparent that the concern in these studies has been to document differences in the error rates associated with various dimensions of meaning. As the focus of the present research is not directed toward the meaning variation of subject and predicate terms, further discussion of these variables is deferred to other sources -- notably the review by Johnson (1968).

The second approach to explaining syllogistic reasoning errors has been concerned with documenting and explaining the effects of the "structural properties" of the syllogism. "Structural properties" here refers to those characteristics of the classical categorical syllogism (e.g., All X are Y; All Z are X; therefore, all Z are Y.) which remain invariant across instances and by virtue of

which any set of three propositions may be classified a syllogism or a non-syllogism. It is this second approach which is most consonant with the thrust of the present research.

Since the validity of a syllogistic conclusion is solely determined by the form or structure of the argument, it is necessary to experimentally determine the effect of these variables. Hopefully, such a documentation will provide some insight into the relative influence of these variables in the inference processes underlying this basic form of deductive reasoning.

Structural Variables:

There are three basic structural variables which combine to determine any one syllogism; syllogistic figure, premise type, and syllogistic mood (Mourant, 1963).

Syllogistic figure refers to the arrangement of the subject term of the conclusion (S), the predicate term of the conclusion (P), and the middle term (M), which does not appear in the conclusion, in the syllogism. Since the syllogism has only

three terms, each of which is used twice, it exemplifies a form of mediated inference, i.e. the relationship between the S and P terms in the conclusion is a necessary consequence of their relationship to a third term (M) in the premises (if the conclusion is valid). However, the presentation of the three terms in the first two premises may vary in the following four ways, called figures:

I	II	III	IV
M-P	P-M	M-P	P-M
S-M	S-M	M-S	M-S

The second variable, premise type, refers to the four possible sentence forms which the individual premises (or propositions) may take. These forms are as follows:

All X are Y	(universal affirmative-A)
No X are Y	(universal negative-E)
Some X are Y	(particular affirmative-I)
Some X are not Y	(particular negative-O)

The A, E, I, and O symbols to the right of the name of each proposition type are the logical shorthand for each proposition.

It should be noted that while these four simple proposition types by no means exhaust the extremely large array of more complex declarative statements capable of being generated by a person, it is logically possible to translate many of these more complex declarative statements into one of these four basic forms by replacing the logical variables X and Y with the appropriate subject and predicate terms respectively. It will be recalled that the validity of a syllogistic conclusion is not affected by the meaning (or complexity) of the subject and predicate terms -- what is relevant is just the form of the argument, which is captured by these four propositional types when they combine in a syllogism.

Returning from this brief digression, it should be noted that the premise type variable actually consists of the interaction of two other variables -- quantification and qualification. Quantification refers to the universality or particularity of the premise as designated by the use of "all" or "no" in the universal premises and "some" in the particular premises. Qualification refers to the affirmative or negative stature of the proposition. Affirmation is shown in the A and I premises

by the words "All...are..." and "Some...are..." while negation is shown in the E and O premises by "No...are..." and "Some... are not...", respectively.

The third variable, syllogistic mood, refers to the position and combination of premise types (A, E, I, or O) within a particular syllogism, i.e., which propositional types respectively appear in the first, second, and third premise (conclusion) positions. Since each premise type can appear in any combination with itself or any other propositional type, there are $4^3=64$ possible premise arrangements per syllogistic figure and a total of 256 syllogisms across the four syllogistic figures.

Previous Research on Structural Variables:

At present, the effects of these structural variables have received little attention, in spite of the fact that their psychological importance was recognized as early as 1935 when Woodworth and Sells introduced their notion of the "atmosphere effect" as an explanatory hypothesis for syllogistic reasoning errors. According to their presentation, the propositional variables of quantification and qualification in the premises of a syllogism

(the first two propositions) created a global impression or "atmosphere" which in some way predisposes subjects (Ss) to either infer an invalid conclusion or accept an invalid conclusion as valid (depending upon the task) which is consonant with the global impression. Since its introduction, the atmosphere effect has received intermittant attention as an explanatory hypothesis (Begg and Denny, 1969; Chapman and Chapman, 1959; Sells, 1936; and Simpson and Johnson, 1966). However, the "atmosphere research" has produced little quantitative evidence regarding the relative importance of quantification vs. qualification.

L.T. Frase (1966, 1968) has considered the effect of the propositional variable of quantification and the syllogistic variable of figure on reasoning errors. Frase (1966) found that Ss made significantly more errors in judging the validity of syllogistic conclusions when the conclusions were particular than when they were universal and that this difference could be eliminated by training. In a later study, syllogistic figure was shown by Frase (1968) to have a significant effect on reasoning errors. In this study the same syllogistic moods, without semantic content (i.e., letters replacing the S, P, and M terms), were admini-

stered in all four figures. The results showed a significant difference between the mean number of errors in the first and fourth figures, with the fourth figure producing the most errors. The mean number of errors in the second and third figures were identical and fell between the means for the first and fourth figures. It should be noted that in the two latter studies only a small sample of the 64 syllogistic moods were used and that these moods were chosen because they violated the same logical rule.

The purpose of the present study is to investigate the relative predictive importance of the propositional variables of quantification and qualification. Of primary interest is to determine the nature of the predictive importance of the propositional variables and the extent of their interaction.

METHOD

Stimulus Materials:

The stimulus material consisted of three independently randomized lists of 64 syllogisms, each of which contained one instance of each syllogistic mood in the fourth figure. Since the total possible mood-figure combinations number 256, the stimulus syllogisms

only in the fourth figure were used in order to prevent S fatigue and confounding due to figure effects. The fourth figure was chosen because it contains the largest number of valid syllogistic moods (5) and therefore maximized the number of valid syllogisms without duplicating or deleting moods. (The experimental syllogisms and their order of appearance can be found in Appendices A and B respectively).

The S, P, and M terms in each syllogism were letter variables, which were randomly chosen from the alphabet and randomly assigned to groups of three letters each. Four groups of letters were chosen (L-S-P, J-C-M, Q-V-X, and B-Z-N) and randomly assigned to each syllogistic mood in each list with the restriction that each group appear equally often throughout the list and that two consecutive syllogisms could not have the same letter terms. In addition, the order of appearance for each letter in a group was randomly determined for each syllogism. The syllogisms were then separately typed in the center of white unlined 3" x 5" index cards using the format:

All X are Y.
All Y are Z.
Therefore, all Z are X.

Procedures:

The subjects in this experiment were University of Alberta introductory psychology students who participated as part of their course requirements and who had no previous training in logic. Twenty-five Ss received list 1, twenty-six Ss received list 2, and twenty-seven Ss received list 3, which made a total of 78 subjects. All Ss were tested individually.

After entering the experimental room and being seated across a plain table from the experimenter (E), each S was given a typed copy of the instructions and asked to read them silently while the E read them aloud. The instructions were as follows:

> "I am going to show you a series of cards. Each card will contain one (1) syllogism. Your task is to:
>
> 1. Read each syllogism aloud.
> 2. Decide whether the conclusion of the syllogism on that card is valid or invalid, i.e., does the conclusion "follow" from the two (2) preceding statements.
> 3. Tell me what you have decided.
>
> You may re-read each syllogism as often as you wish, but you must decide whether the conclusion is valid or in-valid. Please work as quickly as possible, but do not sacrifice accuracy for speed.
>
> Please note that in the following syllogisms the conclusion is always the last (third) statement and is always preceded by the word "Therefore".
>
> Remember, your task is to read each syllogism aloud and tell me whether the conclusion is valid or invalid, once you have decided.
>
> Are there any questions?"

Answers to all questions regarding the task were paraphrases of the

original instructions except when the S asked what a syllogism was. In this case, S were told that a syllogism was a classical form of deductive argument and given the example, "All men are mortal; Aristotle is a man; therefore, Aristotle is mortal".

Immediately after administering the instructions, the E presented the first syllogism by placing the first card on the table in front of the S. If the S failed to read the syllogism aloud, he was reminded of this requirement by the E before proceeding to the next card. If a syllogism was misread, the S was asked to re-read the card. The S's responses were recorded by the E on a dittoed record sheet which remained out of the S's field of vision throughout the experiment. After the response was recorded, the stimulus card was placed face down on the table and the next stimulus card was presented. In all cases, the S received no feedback as to the accuracy of his response. The total testing time was between 20 and 30 minutes per subject.

RESULTS

For the purpose of analyzing the data, six independent variables were defined such that each variable represented the binary scaling of either the quantitative or qualitative aspect of one syllogistic proposition (e.g., a premise or the conclusion). Each

quantitative variable received a value of zero (0) if the proposition in question was particular or a value of one (1) of the proposition was universal (see Table I). Similarly, the qualitative variables received a value of zero (0) for a negative proposition or a value of one (1) for an affirmative proposition. In this way, the logical character of each syllogism could be expressed by the vector of values on the six independent variables summarized in Table I.

Nuisance Variables:

Before pursuing the main analyses, let us consider the question of confounded data. In order to detect the presence of an order effect in the Ss' judgements, the product moment correlation between the number of acceptance responses per syllogism in each list and the position of each syllogism in each list was computed to be $r = + .087$, thus ruling out an order effect. All syllogisms (N=64) were included in this analysis.

A second "nuisance variable", list differences, was investigated by means of a split-plot analysis of variance. Due to computer work-space limitations, each syllogism (N=64) was treated

TABLE I

Independent Variable Specification

Variable	Definition
X_1	First Premise -- Quantification
X_2	Second Premise -- Quantification
X_3	Conclusion -- Quantification
X_4	First Premise -- Qualification
X_5	Second Premise -- Qualification
X_6	Conclusion -- Qualification

as a different level of the experimental factor A, with each of the three experimental lists (L) serving as plots. The N for each plot equaled 25 and was obtained by randomly eliminating one S from List II and two Ss from List III. The results, as displayed in Table II, show that the only significant source of variation in this analysis was the main effect for factor A ($p < .001$). The main effect for lists (factor L) and its interaction with A are both insignificant, indicating the absence of differences in acceptance rates due to list effects.

Analyses:

The data analysis proceeded in two steps which consisted of the multiple linear regression of the proportion of Ss accepting the syllogistic conclusions as valid (dependent variable) on the six independent variables and a 2x2x2x2x2x2 complete factorial analysis of variance. All computations were made on the University of Alberta IBM equipment using standard analysis of variance and least square regression routines. (The proportion of acceptance responses per syllogism, in each list, are displayed in Appendix C).

TABLE II

Results of the Split-Plot Analysis

of Variance for List Differences

(L = lists; S = subjects; A = syllogisms).

Source	Mean Square	d.f.	F
L	.412	2	.958
A	7.349	63	52.077*
S(L)	.430	72	
LxA	.141	126	1.065
SA(L)	.133	4536	

* $p < .001$

TABLE III

Results of the Linear Regression of Y on $X_1 \ldots X_6$

And the First and Second Order Interactions

Of the Predictor Variables within a Propositional Dimension.

Parameter	b coefficient	t values
X_1	-6.118	-0.824
X_2	-6.191	-0.834
X_3	-51.75	-7.255*
X_4	1.883	0.254
X_5	8.255	1.06
X_6	-17.500	-2.453*
$X_1 \times X_2$	-21.88	-2.019*
$X_1 \times X_3$	14.37	1.396
$X_2 \times X_3$	14.07	1.366
$X_1 \times X_2 \times X_3$	28.77	1.924*
$X_4 \times X_5$	-23.01	-2.143*
$X_4 \times X_6$	-3.63	-0.353
$X_5 \times X_6$	-10.38	-0.983
$X_4 \times X_5 \times X_6$	48.13	3.192*

$R^2 = .7545$ df = 44

*$p < .05$

Regression Analysis:

In this analysis the proportion of Ss accepting a conclusion as valid (Y), i.e. the estimated probability that a conclusion is judged to be valid, was regressed on the six predictor variables as well as all of the first and second order interactions within the two propositional dimensions. Mathematically the regression surface was of the form:

$$\dot{Y} = b_o + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_{12}X_1X_2 + b_{13}X_1X_3 + b_{23}X_2X_3 + b_{123}X_1X_2X_3 + b_{45}X_4X_5 + b_{46}X_4X_6 + b_{56}X_5X_6 + b_{456}X_4X_5X_6$$

Where:

$\dot{Y}$ = predicted proportion of acceptance responses

b_o = additive constant

b_{ijk} = b coefficient for variable $X_iX_jX_k$

X_i = observed score variable i

Due to computer workspace limitations a complete cubic regression was not possible. Only the data for the 59 invalid syllogisms was used in order to avoid possible confounding due to actual differences in logical validity.

The results, as shown in Table III, indicate that the quantification and qualification of the conclusion (sources X_3 and X_6 respectively) were inversely related to the proportion of Ss accepting syllogistic conclusions. That is, the estimated probability of an S accepting a syllogistic conclusion as valid was highest when the conclusion was particular in quantification and when the conclusion was negative in qualification.

As shown in Table III the first order interactions for both the quantitative and qualitative dimensions of the first two premises (X_1 x X_2 and X_4 x X_5 respectively) yielded significant b-coefficients.

Figure I graphically represents the interaction of the quantitative variables X_1 and X_2 and indicates that the conclusions of syllogisms with particular second premises ($X_2 = 0$) had a higher probability of acceptance than the conclusions of syllogisms with universal second premises, regardless of the quantification of the first premise (X_1). In addition, the data indicate that the quantification of the first premise had its largest

TABLE IV

Mean Estimated Probabilities of
Accepting a Conclusion for the First Order
Regression Interactions

$X_1 \times X_2$ Interaction

		$X_1=$ 0	$X_1=$ 1
$X_2=$	0	.412	.397
	1	.397	.309

$X_4 \times X_5$ Interaction

		$X_4=$ 0	$X_4=$ 1
$X_5=$	0	.377	.370
	1	.378	.403

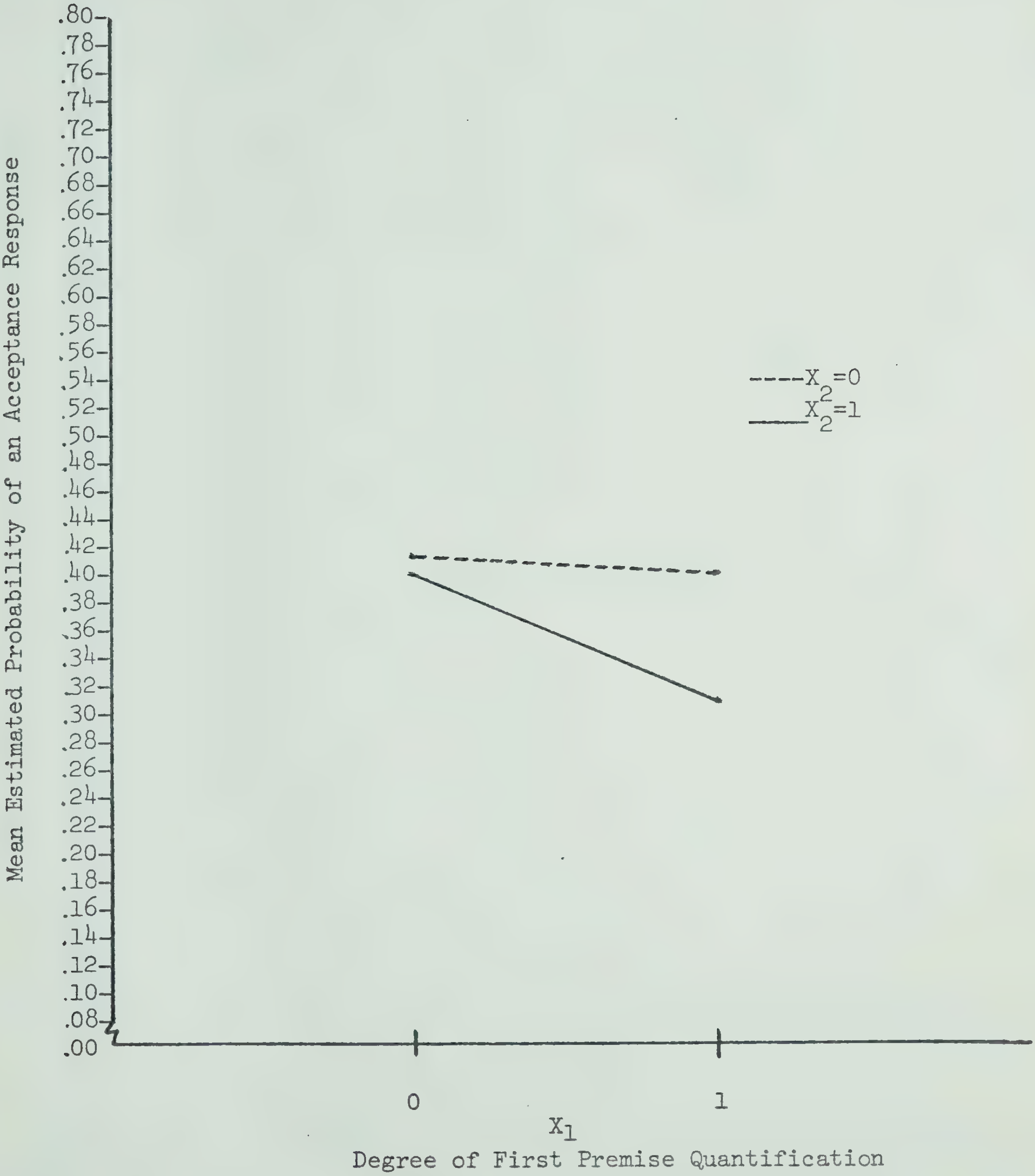


Figure I: The Estimated Probability of an Acceptance Response at Various Levels of First Premise Quantification (X_1) and Second Premise Quantification (X_2).

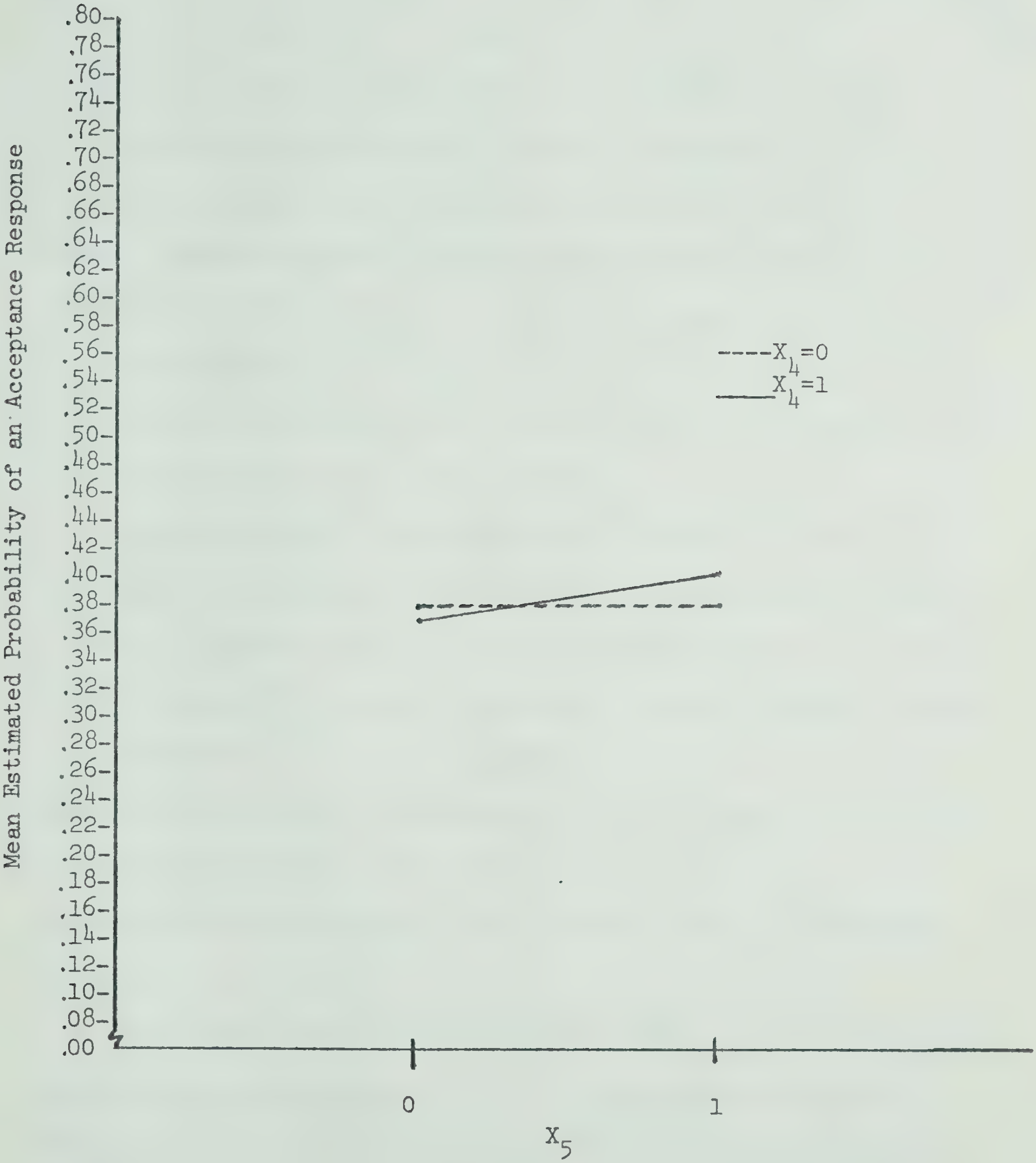


Figure II: The Estimated Probability of an Acceptance Response at Various Levels of First Premise Qualification (X_4) and Second Premise Qualification (X_5).

effect on acceptance probabilities for conclusions when those conclusions are associated with universal rather than particular second premises. For syllogisms with universal second premises, acceptance probabilities were highest when the first premise was particular. Thus, the acceptance probabilities for syllogistic conclusions were highest when one or both of the premises were particularly quantified. The mean probabilities of acceptance for this interaction are shown in Table IV.

The interaction of the qualitative dimensions of the first and second premises (X_4 and X_5 respectively) is graphically presented in Figure II. This interaction indicates that the probability of accepting a conclusion was highest when the premises agreed in qualification. Also, the qualification of the second premise appeared to only make a difference for the acceptance probabilities of conclusions when the first premise was affirmative. The mean acceptance probabilities for this interaction are also presented in Table IV.

The large second order interaction between the three premise quantification variables (X_1 x X_2 x X_3) is graphically shown in Figure III while the mean acceptance probabilities are displayed

TABLE V

Mean Estimated Probabilities of Accepting a Conclusion for the Second Order Regression Interactions

X_1 x X_2 x X_3 Interaction

Number of Universal Premises

		0	1	2
$X_3 =$	0	.744	.641	.250
	1	.080	.183	.359

X_4 x X_5 x X_6 Interaction

Number of Affirmative Premises

		0	1	2
$X_6 =$	0	.489	.539	.324
	1	.264	.239	.509

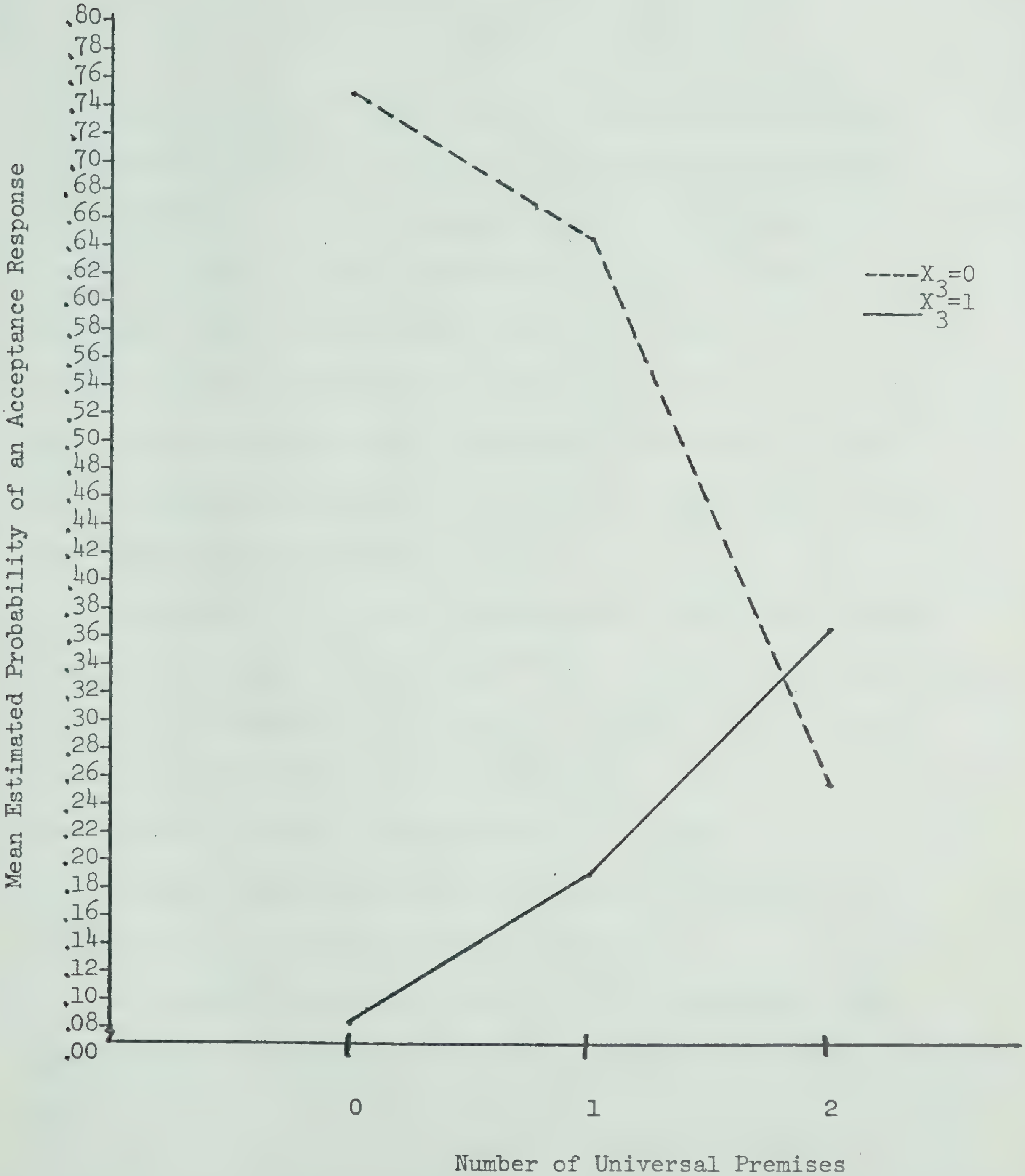


Figure III: The Estimated Acceptance Probabilities for Universal and Particular Conclusions in Syllogisms with Varying Degrees of Premise Quantification.

in Table V. As seen in Figure III the acceptance probabilities for particular conclusions declined as the premise quantification changed from two particular premises to two universal premises. The opposite trend obtained for acceptance probabilities associated with universal conclusions. As a result, particular conclusions were accepted more often than universal conclusions when ever one or more of the premises were particular. Universal conclusions were accepted most often only when both premises were universally quantified.

The second order interaction among the qualification variables (X_4 x X_5 x X_6) was also significant. As Figure IV and Table V show, the probability of accepting a negative conclusion was higher than the acceptance probability for an affirmative conclusion when one or more of the premises were negative. However, if both premises were affirmative, an affirmative conclusion was accepted more often than a negative conclusion.

The multiple correlation was $R^2 = .7545$, indicating that approximately 75% of the variance was accounted for by this analysis.

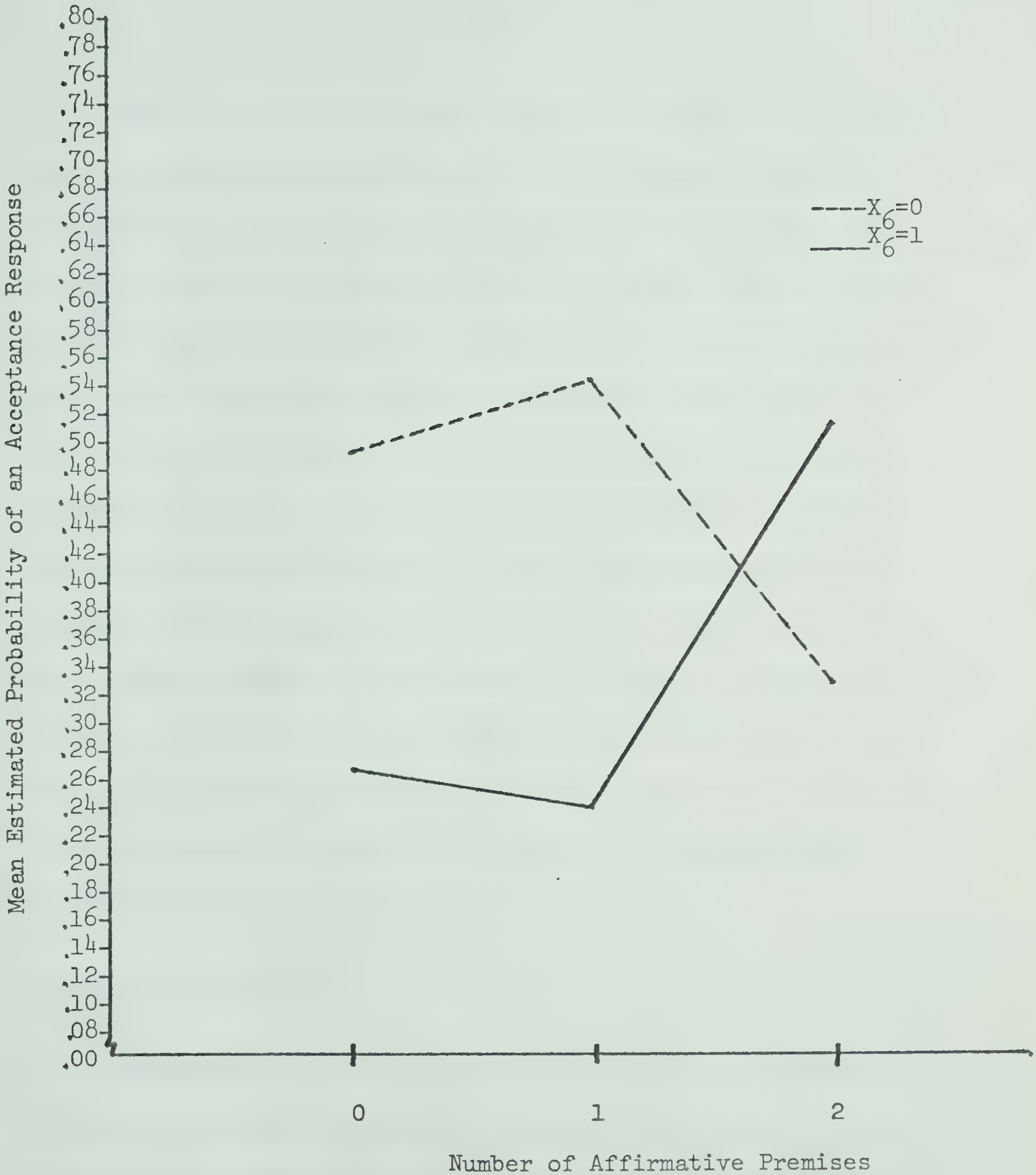


Figure IV: The Estimated Acceptance Probabilities for Affirmative and Negative Conclusions in Syllogisms with Varying Degrees of Premise Qualification.

Based on the b-coefficients from this regression analysis, the predicted acceptance rates (i.e., the predicted number of Ss accepting a conclusion) were computed for the entire experimental array of 64 syllogisms. These predicted values were then plotted against the observed acceptance rates for each syllogism, in Figure V. The mean magnitude of error with this prediction policy was $\bar{X}_e = 10.618$ and the standard error of the estimate was $SE_y = 13.02$. As can be seen from Figure V, the prediction policy derived from the data on invalid syllogisms appears to predict acceptance rates for both valid and invalid syllogisms with approximately equal accuracy. As a result, it appears that differences in the logical validity of a syllogism is an insignificant factor for predicting acceptance rates -- at least when the predictions are based on the variables of propositional quantification and qualification.

Analysis of Variance:

A 2x2x2x2x2x2 complete factorial analysis of variance with 78 replications was computed to determine the presence of significant interactions of greater complexity than those found in

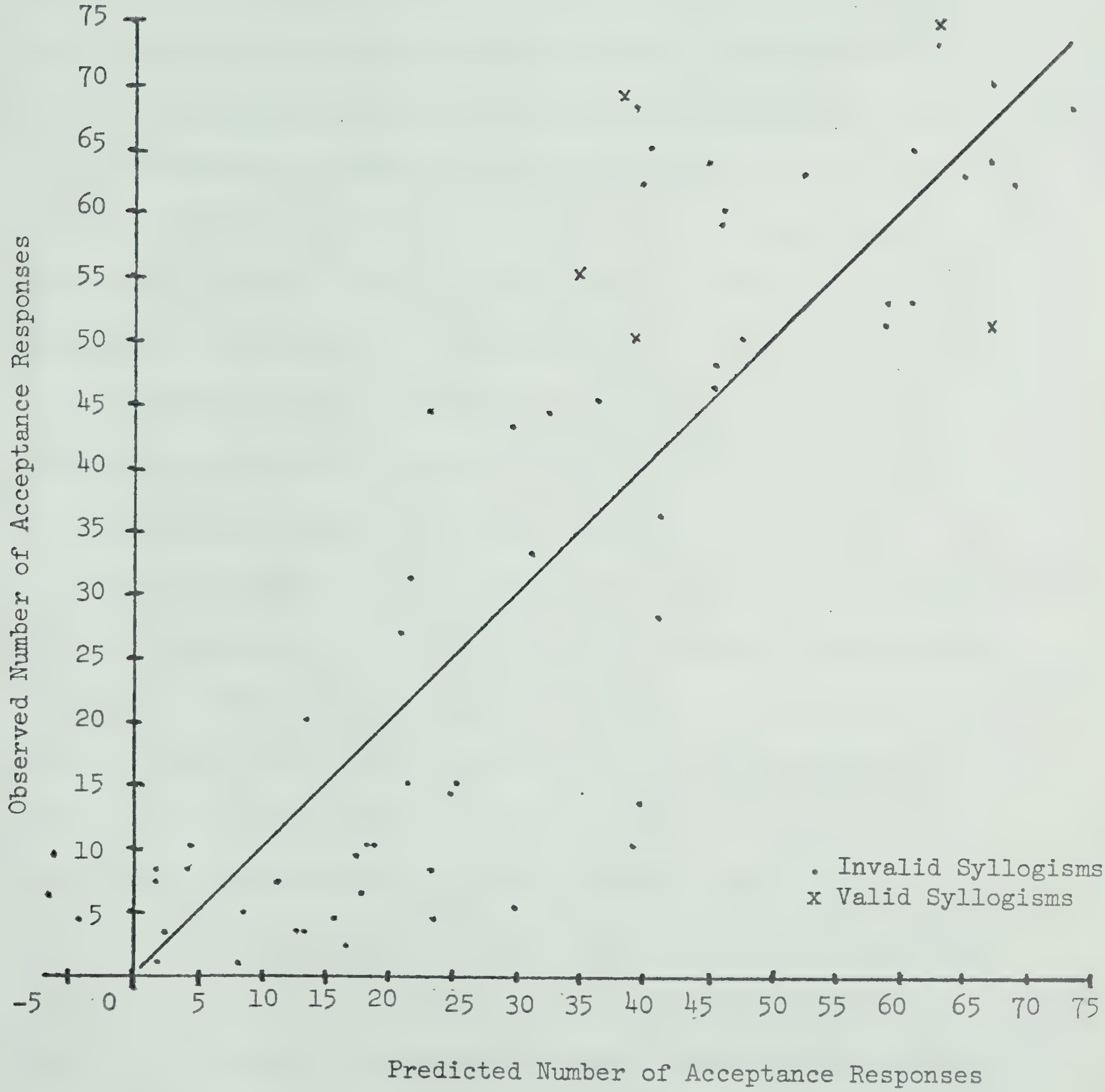


Figure V: Scatter Plot of Predicted Number of Acceptance Responses and Observed Number of Acceptance Responses.

the regression analysis and to explore the possibility of significant interactions between the quantitative variables and the qualitative variables. In this analysis, as stipulated in Table VI, the analysis of variance factors correspond to the six independent variables which served as the basis for the preceding regression analysis. Each cell entry consisted of a one or a zero which indicated an S's acceptance (1) or rejection (0) of the conclusion in each experimental condition - each syllogism being one experimental condition. The data from all 78 Ss and all 64 syllogisms were used in this analysis.

Unfortunately, computer workspace and program limitations made it impossible to obtain both the mean square and appropriate error mean square for each source of variation. Instead, the F ratio for each source was computed by dividing the appropriate mean square by the pooled error term S(ABCDEF). This situation resulted in the conservative F tests shown in Table VII. As indicated in this table, 35 of the 63 sources of variation were significant at the $p < .001$ level. In view of the staggering interpretive difficulties associated with these results, the percentage

TABLE VI

Correspondence of Regression Independent Variables and Analysis of Variance Factors

Regression Variable	Variable Definition	Analysis Variance Factor
X_1	first premise quantification	A
X_2	second premise quantification	B
X_3	conclusion quantification	C
X_4	first premise qualification	D
X_5	second premise qualification	E
X_6	conclusion qualification	F

of the total variance accounted for by each source (coefficient of association, $\hat{\omega}$) was calculated according to the methods outlined in Kirk (1968; p. 198). These statistics were then rank ordered (largest to smallest) and plotted against their ranks as seen in Figure VI. The "natural break" in the continuity of this curve, between the 7th and 8th sources, was chosen as the cut-off point since after this point the remaining sources of variation accounted for approximately 1% or less of the total variance. On this basis, the seven largest sources of variation were chosen for interpretation.

Main Effects:

Of the seven interpreted sources of variation, two were main effects. Factor C, the quantification of the conclusion, while accounting for the largest percentage of the total variance (13.31%), indicated a significant difference between the probabilities of accepting particular and universal conclusions. As can be seen from Table VIII, this difference reflects the pattern found in the regression analysis that particular conclusions had a higher probability of being accepted than universal conclusions.

TABLE VII

Results of 2x2x2x2x2x2 Complete

Factorial Analysis of Variance

Source	Mean Square	d.f.	F
A	2.837	1	20.522*
B	5.322	1	38.503*
C	154.776	1	1119.942*
D	.168	1	1.218
E	.106	1	.767
F	30.313	1	219.291*
AB	1.067	1	7.723
AC	37.906	1	274.220*
BC	43.688	1	316.049*
AD	2.933	1	21.217*
BD	9.607	1	69.504*
CD	3.231	1	23.373*
AE	.0018	1	.013
BE	.088	1	.639
CE	.274	1	1.984
DE	.146	1	1.056
AF	.016	1	.117
BF	2.837	1	20.522*
CF	3.334	1	24.116*
DF	11.063	1	80.031*
EF	5.858	1	42.375*
ABC	3.130	1	22.642*
ABD	.562	1	4.071
ACD	21.683	1	156.859*
BCD	18.391	1	133.046*
ABE	1.659	1	12.001*
ACE	12.620	1	91.298*
BCE	.481	1	3.478
ADE	5.995	1	43.372*
BDE	.899	1	6.505
CDE	.0049	1	.036

TABLE VII (cont.)

Source	Mean Square	d.f.	F
ABF	1.808	1	13.079*
ACF	3.760	1	27.198*
BCF	.899	1	6.504
ADF	21.159	1	153.069*
BDF	1.380	1	9.983
CDF	11.252	1	81.398*
AEF	.168	1	1.219
BEF	3.760	1	27.199*
CEF	.088	1	.639
DEF	11.063	1	80.031*
ABCD	.274	1	1.984
ABCE	4.447	1	32.172*
ABDE	.606	1	4.384
ACDE	.017	1	.119
BCDE	4.329	1	31.317*
ABCF	.218	1	1.577
ABDF	5.587	1	40.416*
ACDF	1.808	1	13.079*
BCDF	7.617	1	55.105*
ABEF	.005	1	.036
ACEF	1.885	1	13.637*
BCEF	2.125	1	15.376*
ADEF	5.192	1	37.564*
BDEF	.954	1	6.899
CDEF	2.209	1	15.978*
ABCDE	.034	1	.245
ABCDF	.954	1	6.904
ABCEF	.795	1	5.753
ABDEF	4.329	1	31.315*
ACDEF	.009	1	.070
BCDEF	1.010	1	7.304
ABCDEF	.899	1	6.502
S(ABCDEF)	681.200	4928	-----

* $p < .001$

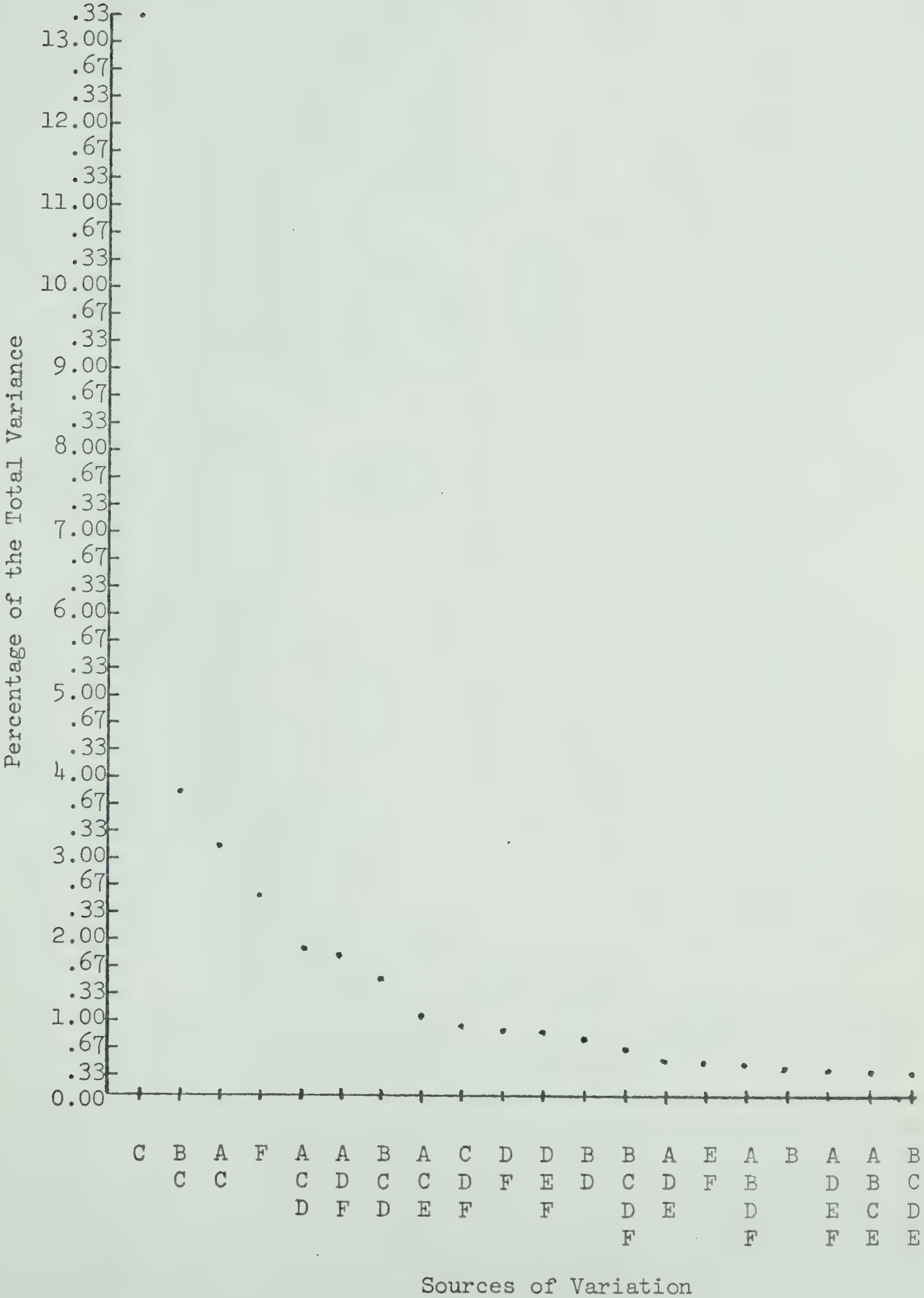


Figure VI: The Percentage of the Total Variance Accounted for by the Twenty Largest Sources of Variation.

TABLE VIII

The Mean Estimated Probabilities of Accepting Conclusions for the C and F Main Effects

C Main Effect

0	1
.546	.194

F Main Effect

0	1
.448	.292

The second interpreted main effect was for Factor F, the qualification of the conclusion, accounting for 2.6% of the total variance. Again, from Table VIII, the estimated probabilities indicate that negative conclusions were accepted more often than affirmative conclusions. This too is consistent with the pattern found in the regression analysis.

First Order Interactions:

The interaction of the quantification of the first premise and the quantification of the conclusion (A x C) is presented in Table IX and Figure VII. This interaction shows that the probability of accepting a particular conclusion was higher than the probability of accepting a universal conclusion regardless of the quantification of the first premise. In addition, Figure VII indicates that the probabilities of accepting a particular conclusion or a universal conclusion were largest when the quantification of the first premise agrees with the quantification of the conclusion. The A x C interaction accounted for 3.2% of the total variance.

The interaction of the quantification of the second premise and the quantification of the conclusion (B x C) as shown in Table IX and Figure VIII, was similar in form to the A x C interaction.

TABLE IX

The Mean Estimated Probabilities of Accepting Conclusions for the Interpreted First Order Interactions

B x C Interaction

		B= 0	B= 1
C=	0	.672	.4199
	1	.133	.255

A x C Interaction

		A= 0	A= 1
C=	0	.657	.435
	1	.131	.257

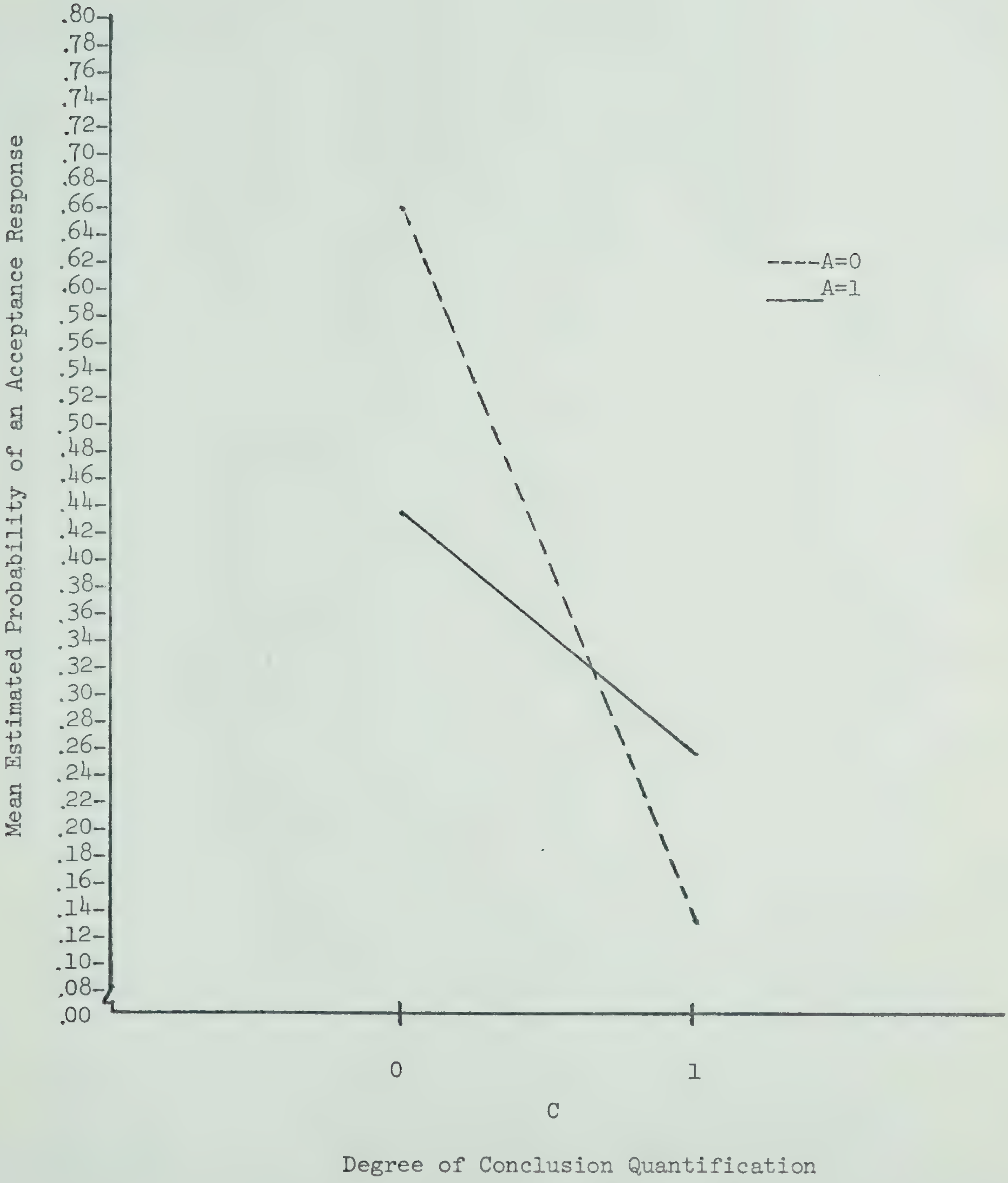


Figure VII: The Estimated Probability of an Acceptance Response at Various Levels of First Premise Quantification (A) and Conclusion Quantification (C).

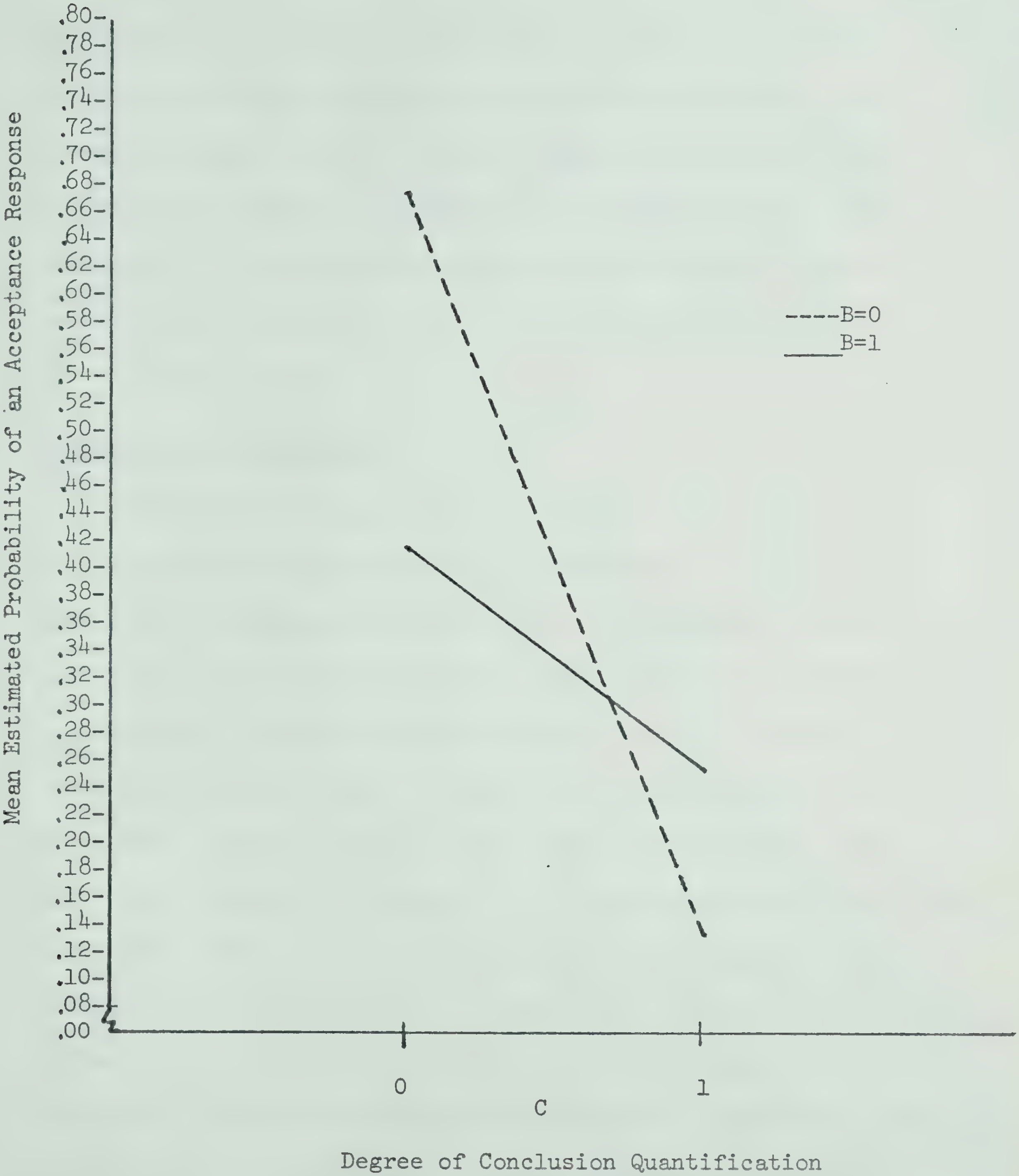


Figure VIII: The Estimated Probability of an Acceptance Response at Various Levels of Second Premise Quantification (B) and Conclusion Quantification (C).

The probabilities of accepting a particular conclusion were consistently larger than the probabilities of accepting a universal conclusion. Figure VIII also indicates that the probabilities for accepting a conclusion were largest when the quantification of the conclusion and the quantification of the second premise were the same. This interaction accounted for 3.7% of the total variance.

Second Order Interactions:

The A x C x D interaction accounted for 1.85% of the total variance. The estimated acceptance probabilities for this interaction are displayed in Table X. Figure IX graphically represents this interaction and indicates that the probability of accepting a syllogistic conclusion was highest when the first premise and conclusion agreed in quantification. This interaction also indicates that the qualification of the first premise did not effect the form of the A x C interaction, but did significantly effect the difference between the acceptance probabilities associated with particular and universal first premises in syllogisms with the same degree of conclusion quantification. This is, a change in the qualification of the first premise, from negative to affirmative, was associated with a convergence of the acceptance probabilities

TABLE X

The Mean Estimated Probabilities
of Accepting Conclusions for the Interpreted
Second Order Interactions

A x C x D Interaction

	at D=0 A= 0	1		at D=1 A= 0	1
C= 0	.728	.325	C= 0	.587	.545
1	.120	.330	1	.141	.184

A x D x F Interaction

	at A=0 D= 0	1		at A=1 D= 0	1
F= 0	.486	.461	F= 0	.516	.329
1	.362	.266	1	.139	.401

B x C x D Interaction

	at D=0 B= 0	1		at D=1 B= 0	1
C= 0	.548	.505	C= 0	.796	.335
1	.181	.269	1	.084	.240

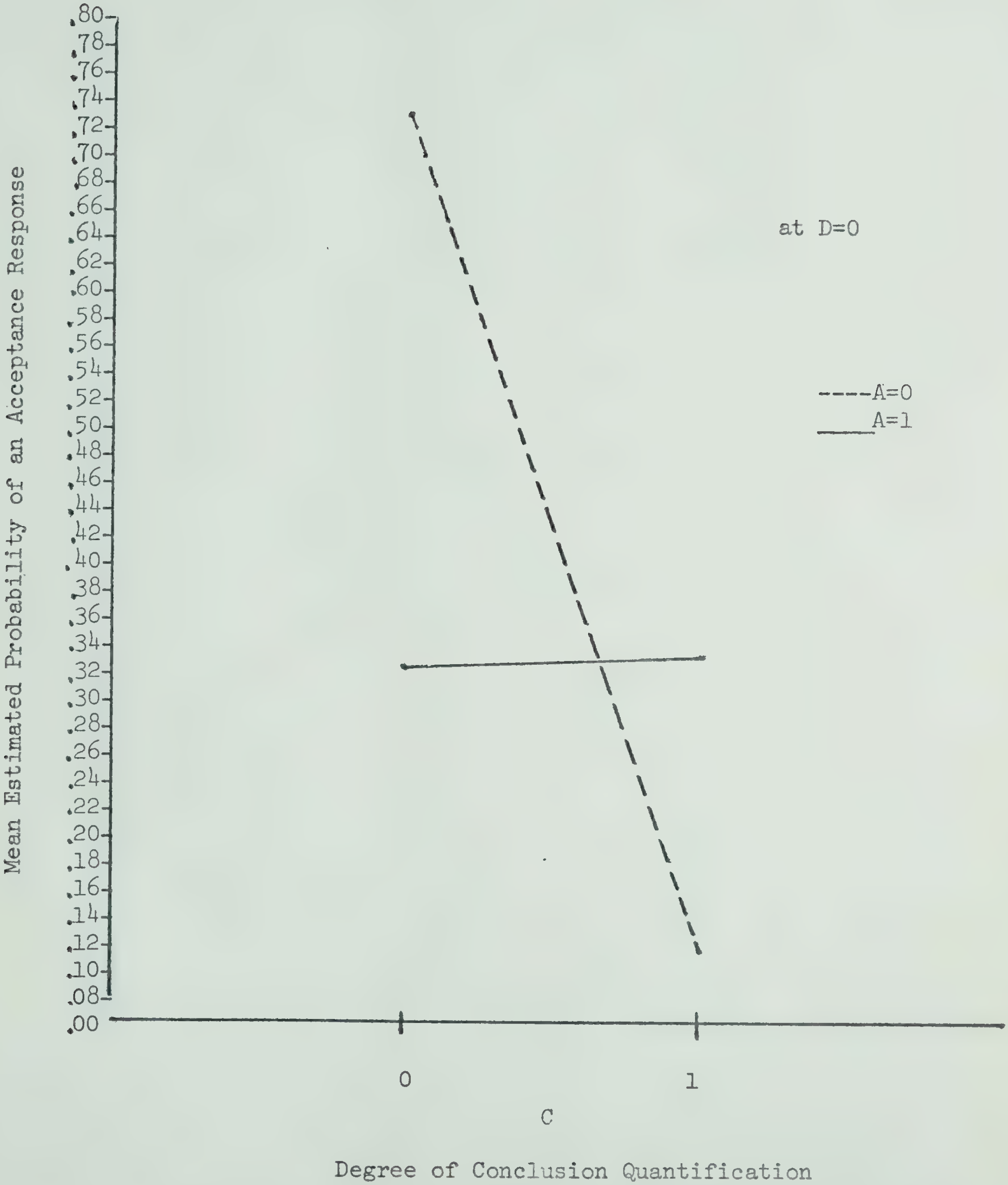


Figure IX (a.): The Estimated Probability of an Acceptance Response for Syllogisms with Negative First Premises (D=0) and Varying Degrees of First Premise Quantification (A) and Conclusion Quantification (C).

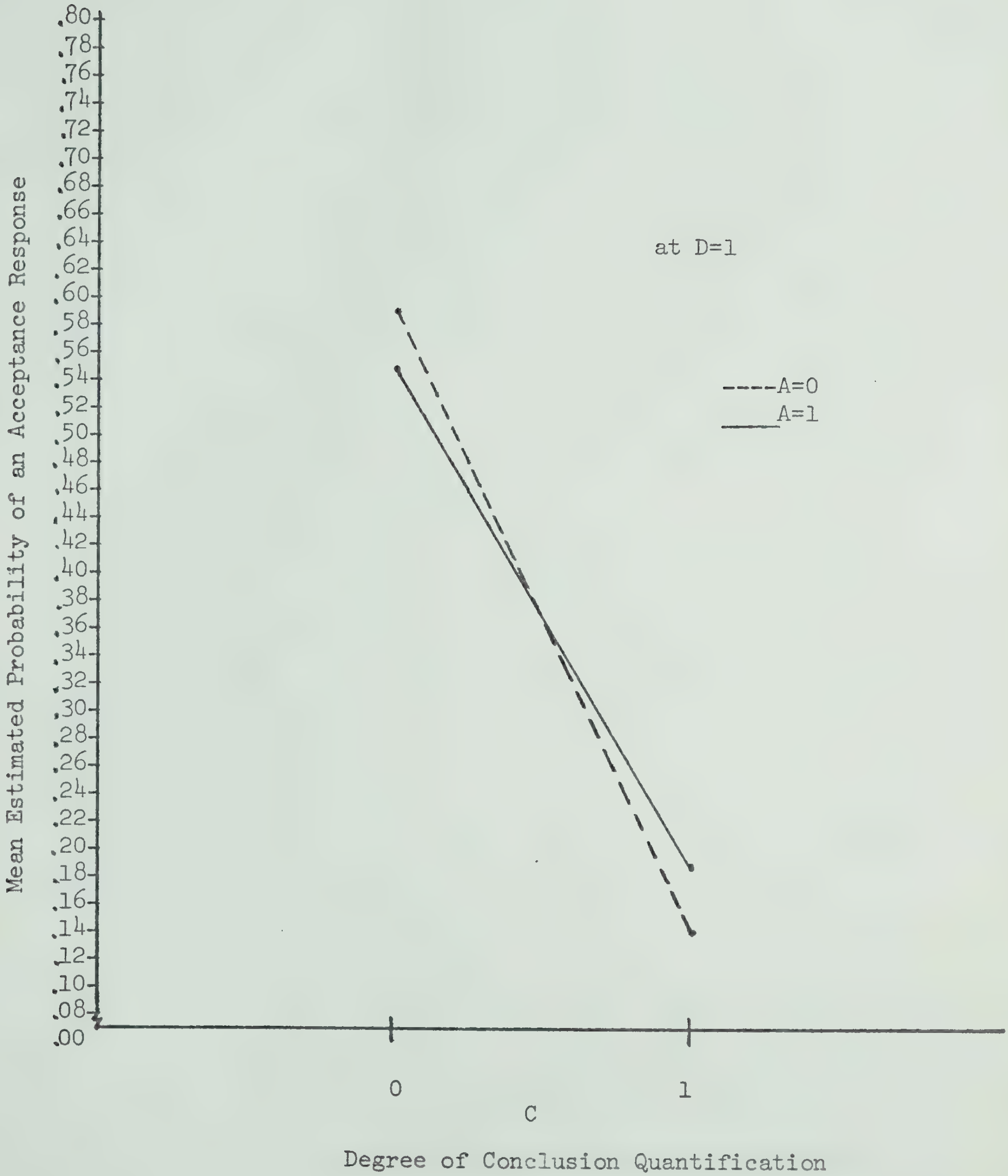


Figure IX (b.): The Estimated Probability of an Acceptance Response for Syllogisms with Affirmative First Premises (D=1) and Varying Degrees of First Premise Quantification (A) and Conclusion Quantification (C).

for universal and particular first premises in syllogisms with the same degree of conclusion quantification. A comparison of Figure IX (a) and Figure IX (b) will elucidate this effect.

It is also interesting to note that by visual inspection the change in the qualification of the first premise primarily effected the acceptance probabilities associated with universal premises, rather than particular premises. In general, particular conclusions were observed to have higher acceptance probabilities than universal conclusions.

The B x C x D interaction is presented in Table X and Figure X. This interaction accounted for approximately 1.57% of the total variance. Figure X shows that the estimated probability of accepting a conclusion was highest when the conclusion and second premise agreed in quantification, regardless of the qualification of the first premise. Also, the probability of accepting a conclusion was highest when the conclusion was particular.

The effect of the qualification of the first premise (D) on the pattern of acceptance probabilities associated with the interaction of the quantification of the second premise and conclusion (B x C) appears to have been just the opposite of the effect D had on the pattern of acceptance probabilities associated with the

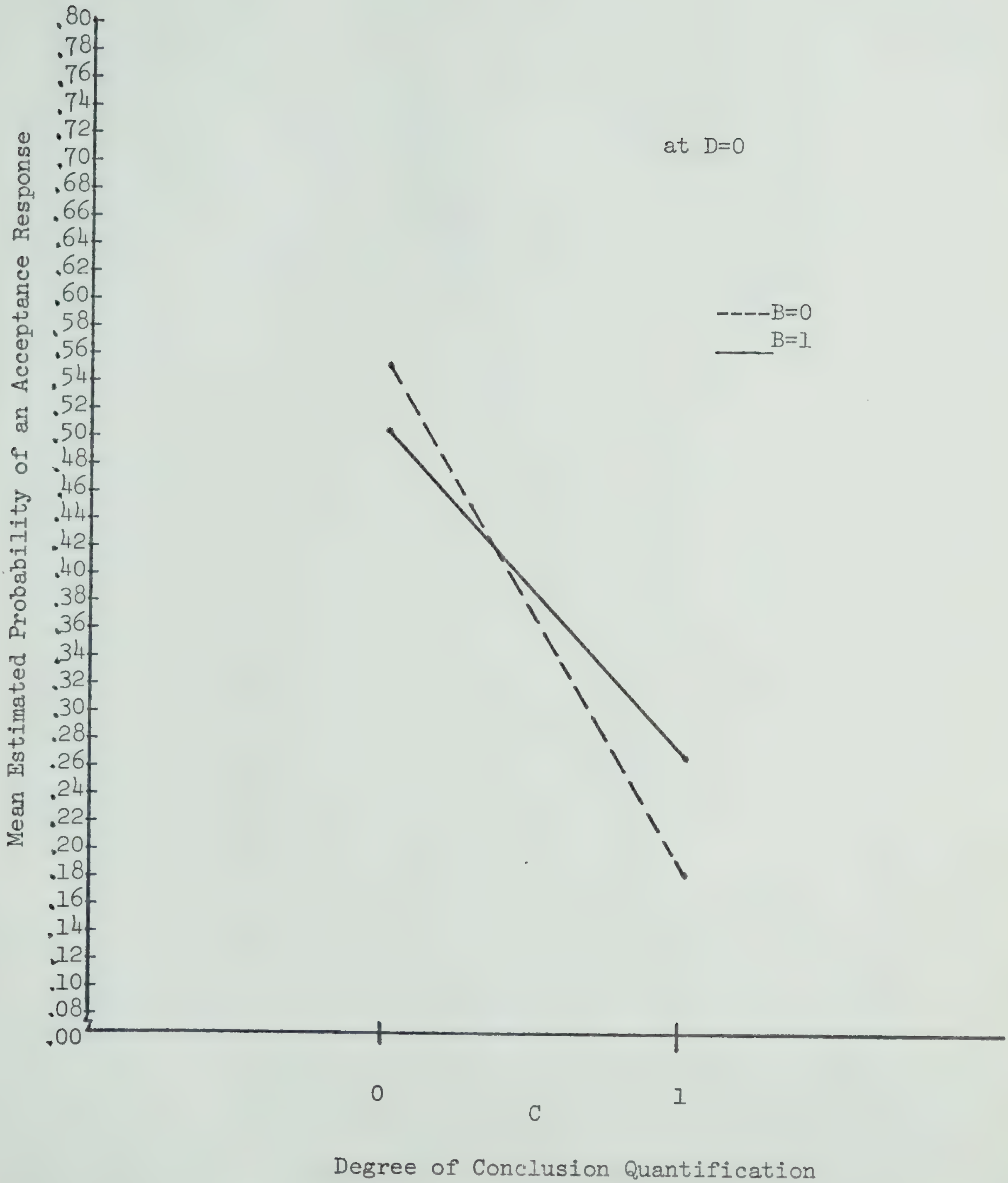
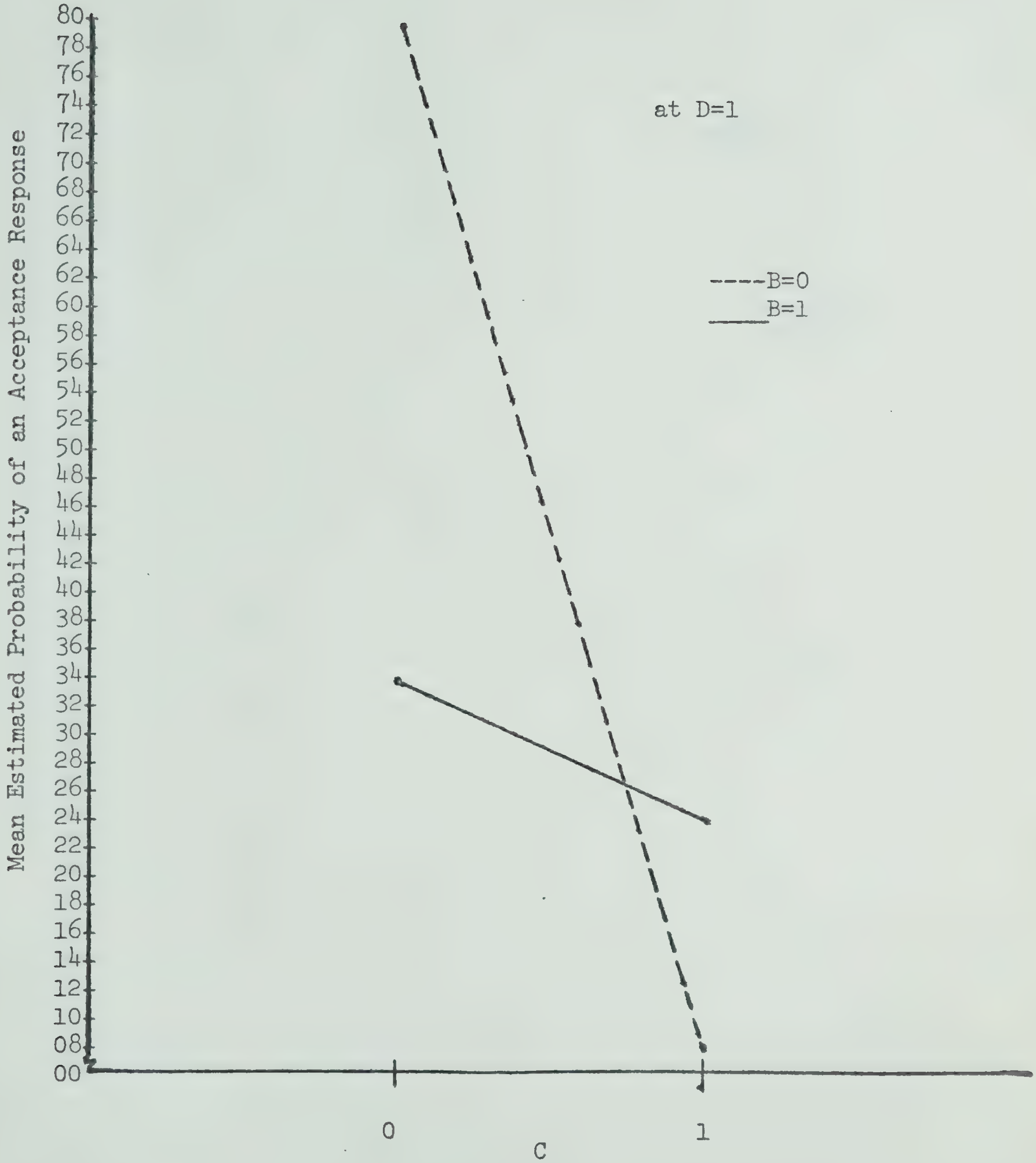
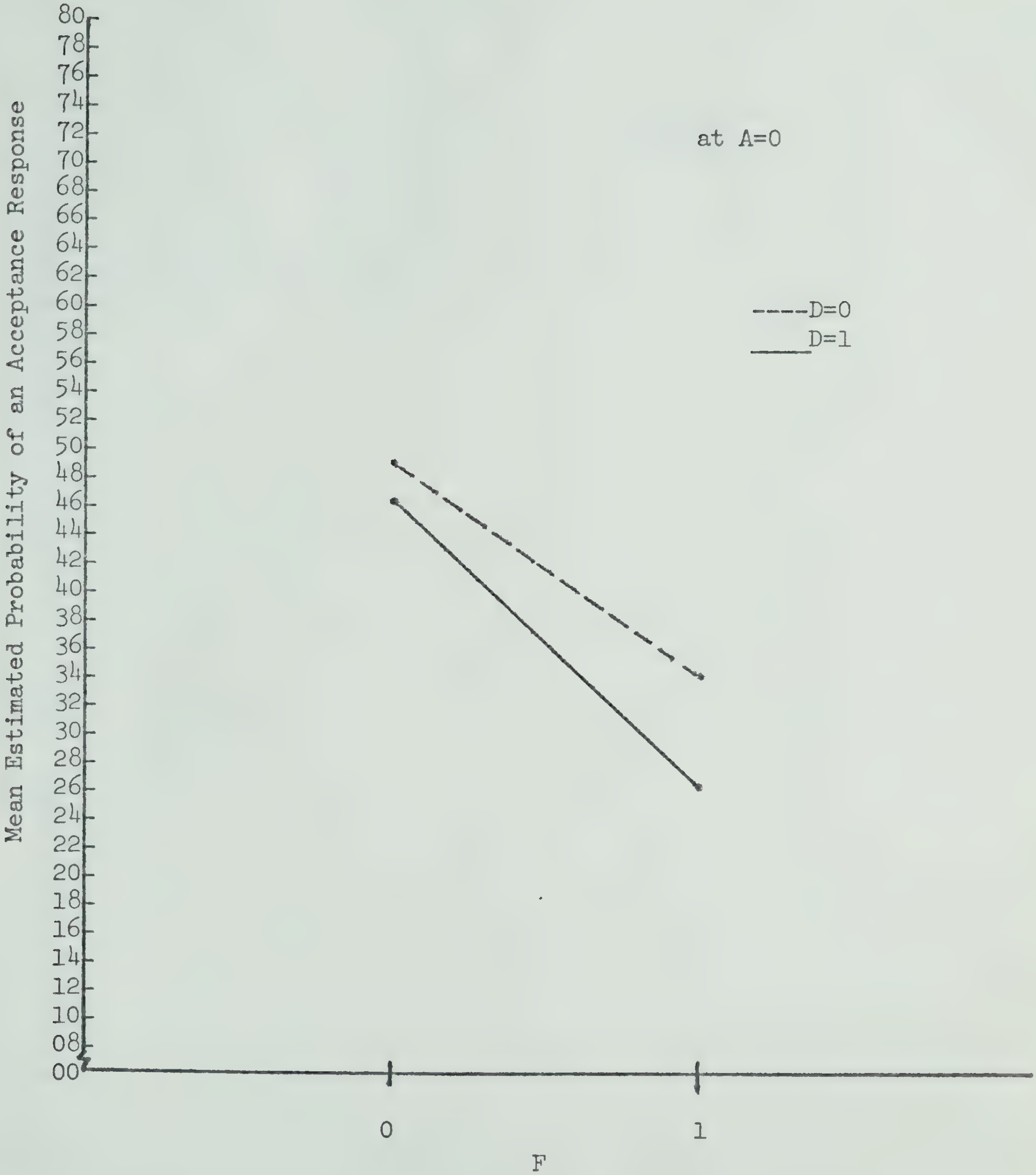


Figure X (a.): The Estimated Probability of an Acceptance Response for Syllogisms with Negative First Premises (D=0) and Varying Degrees of Second Premise Quantification (B) and Conclusion Quantification (C).



Degree of Conclusion Quantification

Figure X (b.): The Estimated Probability of an Acceptance Response for Syllogisms with Affirmative First Premises (D=1) and Varying Degrees of Second Premise Quantification (B) and Conclusion Quantification (C).



Degree of Conclusion Qualification

Figure XI (a.): The Estimated Probability of an Acceptance Response for Syllogisms with Particular First Premises (A=0) and Varying Degrees of First Premise Qualification (D) and Conclusion Qualification (F).

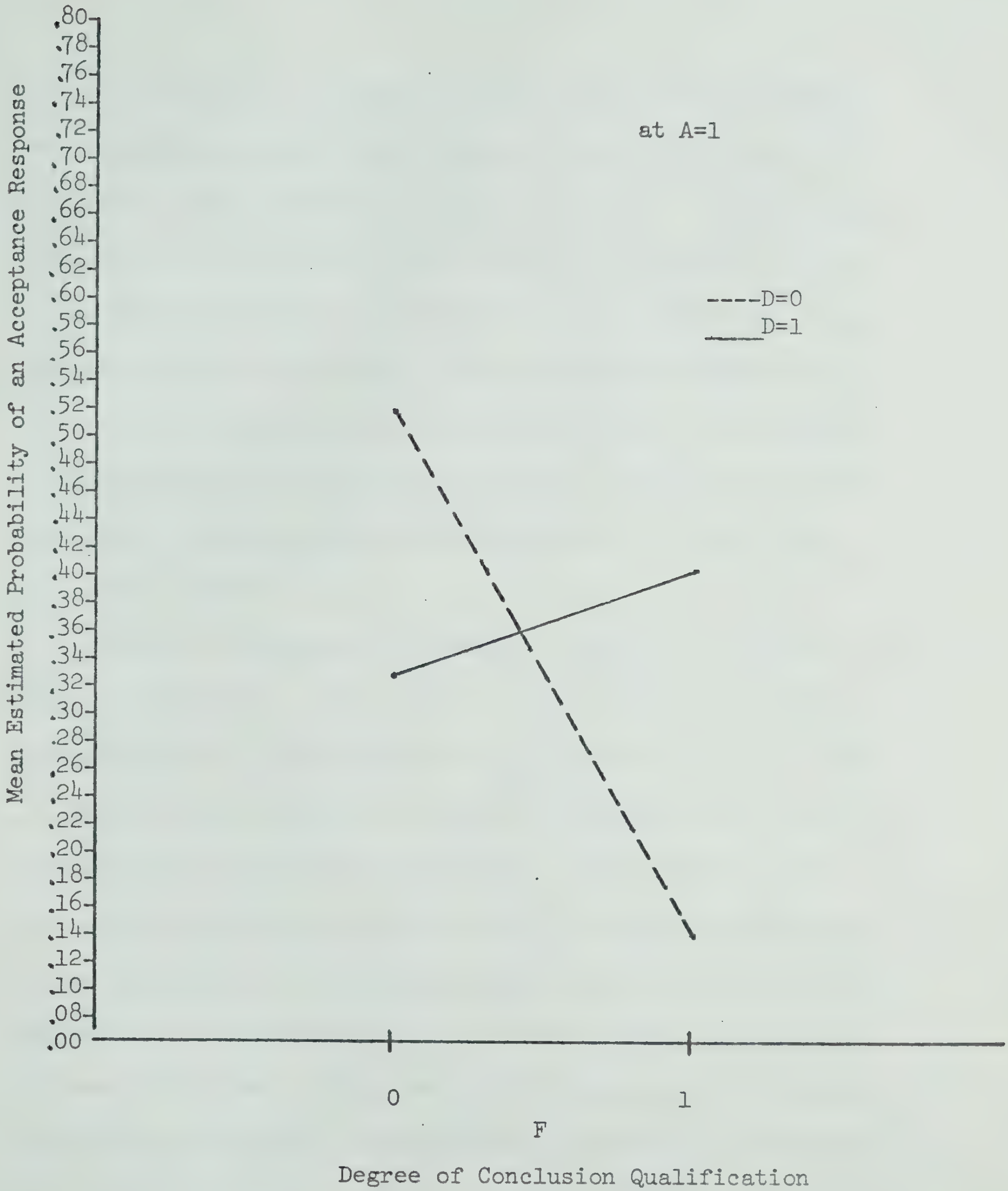


Figure XI (b.): The Estimated Probability of an Acceptance Response for Syllogisms with Universal First Premises (A=1) and Varying Degrees of First Premise Qualification (D) and Conclusion Qualification (F).

A x C interaction. As Figure X shows, the difference between the acceptance probabilities associated with particular and universal second premises at the same level of conclusion quantification was minimized by negative first premises and maximized by affirmative first premises. In its essence, a change in the qualification of the first premise from negative to affirmative was accompanied by a divergence of the acceptance probabilities for conclusions associated with particular and universal second premises in syllogisms with the same level of conclusion quantification.

Figure XI graphically represents the A x D x F interaction which accounted for 1.81% of the total variance. The estimated probabilities of acceptance for this interaction can be found in Table X. From Figure XI it can be seen that the acceptance probabilities associated with negative first premises (D=0) were higher than those associated with affirmative first premises regardless of the qualification of the conclusion, when the first premise was particular. However, when the first premise was universal, the probability of acceptance was highest when the first premise and conclusion agreed in qualification.

Additionally, Figure XI indicates that a change in the quantification of the first premise, from particular to universal, differentially effected the difference that the qualification of the conclusion had on the acceptance probabilities associated with negative and affirmative first premises. When the first premise was particular the acceptance probabilities for conclusions associated with both negative and affirmative first premises decreased as the quality of the conclusion changed from negative to affirmative. However, when the first premise was universally quantified, the acceptance probabilities associated with affirmative first premises increased as the quality of the conclusion changed from negative to affirmative, while the probabilities associated with negative first premises decreased with a comparable change in conclusion qualification. As a result, negative first premises were associated with higher acceptance probabilities than affirmative first premises, except in the case when the first premise was universal-affirmative (A=1, D=1) and the conclusion was affirmatively qualified (F=1).

DISCUSSION

While difficulties with the analyses preclude definitive statements about the relationship between the propositional variables considered herein and the way Ss make judgments about

the validity of syllogistic conclusions, several interesting preferences are indicated.

The most striking finding of this study is undoubtedly the consistency with which Ss showed a preference for accepting particular conclusions. In both analyses this preference was evidenced by a significant main effect for the conclusion quantification variable. Further support was found in the interactions of the conclusion quantification variable with other quantitative variables. In these interactions higher estimated probabilities of acceptance were observed for particular conclusions than for universal conclusions.

In addition, the A x C x D and B x C x D interactions suggest that S preferences for particular conclusions is not altered, at least in principle, by the qualification variables. In both cases, the primary effect of a change in the first premise qualification, appears to have been to alter the relative discrepancy between the acceptance probabilities associated with universal and particular first premises rather than shifting the preference for accepting particular conclusions to a preference for accepting universal conclusions.

In addition to S preferences for particular conclusions, the present study also documents the tendency of Ss to more readily accept syllogistic conclusions when one or more of the premises agrees in quantity with the conclusion. As mentioned previously this effect has been called the "atmosphere effect". More specifically, this tendency represents a quantitative atmosphere effect as opposed to a qualitative atmosphere effect which is considered below.

The $X_1 \times X_2 \times X_3$ interaction from the first analysis indicates that syllogistic conclusions have the highest probability of being accepted when the conclusion agrees in quantity with both premises. In the case of mixed premise quantification, i.e., one universal and one particular premise, particular syllogistic conclusions have the highest probability of being accepted. As a result, the quantitative atmosphere effect reflects the tendency of Ss to accept universal conclusions more often than particular conclusions only when both premises are universally quantified.

Support for this tendency was also found in the two and three factor interactions involving the quantification variable

for the conclusion and one other quantification variable. In each of these interactions acceptance probabilities for the conclusion were highest when the quantity of the conclusion and premise were the same.

The data also suggest that the quantitative atmosphere effect is not substantially altered by the quality of the premises. In both the A x C x D and the B x C x D interactions, the quality of the first premise did not alter the relative pattern of acceptance probabilities associated with universal or particular premises and conclusions. Instead the effect of the quality of the first premise appears to have been restricted to the difference in the strength of S preferences for the atmosphere conclusion relative to the non-atmosphere conclusion.

It should be noted that the documentation of the relationship between the qualification variables and the quantitative atmosphere effect remains incomplete. However, the above noted tendency suggests that the effect of premise qualification on quantitative atmosphere preferences is one of degree rather than kind.

Before considering the findings concerning the qualification variables it is theoretically important to note that the observed

S preference for particular conclusions, as reflected by the significant main effect for the conclusion quantification variable, may be an artifact of a quantitative atmosphere effect. Since 48 or 75% of the original array of 64 syllogisms contained one or more particular premises, it seems very likely that this S preference is the result of atmosphere responding rather than a S preference for particular propositions *per se*. However, the present study offers no conclusive evidence for answering this question.

Turning to the qualitative variables, the main effect for the qualification of the conclusion in both analyses indicated an S preference for accepting negative conclusions. This preference was also supported by the interaction of the qualitative conclusion variable with the qualitative variable for the first premise (A x D x F interaction).

As with the quantitative variables, the present study suggests the presence of an atmosphere effect with respect to propositional qualification. The first analysis showed that Ss displayed higher probabilities of accepting affirmative conclusions than negative conclusions when both premises were affirmative. In the cases of mixed premise qualification, one affirmative

and one negative premise, and complete premise negation Ss accepted negative conclusions with higher probabilities than affirmative conclusions.

Additional support for a qualitative atmosphere effect was not unequivocally forthcoming. The pattern of acceptance probabilities for the interaction of the qualitative characteristics of the first premise and the conclusion support an atmosphere interpretation only when the first premise is universally quantified. In this case the acceptance probabilities associated with conclusions are highest when the qualification of the first premise agrees with the qualification of the conclusion. However, when the first premise is particular, the pattern of acceptance probabilities does not support the atmosphere interpretation since the probability of accepting a conclusion associated with a negative first premise was consistently higher than the acceptance probabilities associated with affirmative first premises regardless of the qualification of the conclusion. In short, the data hint that atmosphere responding, with respect to qualification, appears to occur only under the universal condition of premise quantification.

Unfortunately the relationship between premise quantification and S preferences for syllogistic conclusions based on propositional qualification remain inadequately documented. At best, the available information does indicate the presence of a qualitative atmosphere effect which may be dependent upon propositional quantification for its expression. More definitive conclusions can be little more than speculative at this time.

The lack of clarity with respect to a qualitative atmosphere effect also lends confusion to the understanding of the observed S preference for negative conclusions. Like the preference for particular conclusions, the preference for negative conclusions may be an artifact of qualitative atmosphere responding since 75% of the test syllogisms contained one or more negative premises. However, if qualitative atmosphere responding does occur only under certain conditions of premise quantification and not others, and if negative premises are preferred in all of those cases where atmosphere responding does not occur, it would appear that negatively qualified propositions are, at least under certain conditions, more acceptable as syllogistic conclusions for reasons other than association with like

qualified propositions. In any case, these questions require further investigation.

In summary, the present study documents a consistant S preference for accepting particularly quantified syllogistic conclusions. A quantitative atmosphere effect was observed such that particular conclusions were accepted more often than universal conclusions when one or more of the premises was particularly quantified. As a result of the quantitative atmosphere effect, it was thought that the observed preference for particular conclusions, may in fact, represent an artifact of atmosphere responding rather than a preference for particular conclusions *per se*. This question awaits further experimentation.

With respect to the quantitative atmosphere effect, the present study suggested that the premise qualification variables may not substantially effect the appearance of atmosphere responding. Instead, premise qualification appeared to effect only the relative strengths of atmosphere and non-atmosphere responses while maintaining the atmosphere response patterns. Again, further investigation is required.

A consistant documentation of the S preference for accepting negative syllogistic conclusions is also provided by the present study. In addition, the appearance of a qualitative atmosphere effect in the data, such that negative conclusions were accepted more often than affirmative conclusions when one or more of the premises was negatively quantified, raises the question of an artifactual S preference for negative conclusions. Unfortunately, interpretive difficulties, due to computer workspace and program limitations as well as only conditional support for a qualitative atmosphere effect, make precise speculation about the relationship between the observed preference for negative conclusions and a qualitative atmosphere effect very tenuous.

In conclusion, the present study has identified specific preferences for the quantitative and qualitative characteristics of propositions which Ss judge to be valid syllogistic conclusions. This study has also documented possible relationships both between and within the propositional variables of quantification and qualification as these variables appear in the categorical syllogism. Lastly, by raising more questions than it has answered, the present study has indicated directions for further research.

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APPENDIX A

List of Experimental Fourth Figure Syllogisms

Syllogistic Mood	Syllogism
OOO	Some X are not Y. Some Y are not Z. Therefore, some Z are not X.
OOI	Some X are not Y. Some Y are not Z. Therefore, some Z are X.
OIO	Some X are not Y. Some Y are Z. Therefore, some Z are not X.
OII	Some X are not Y. Some Y are Z. Therefore, some Z are X.
IOO	Some X are Y. Some Y are not Z. Therefore, some Z are not X.
IOI	Scme X are Y. Some Y are not Z. Therefore, some Z are X.
IIO	Some X are Y. Some Y are Z. Therefore, some Z are not X.
III	Some X are Y. Some Y are Z. Therefore, some Z are X.

OOE	Some X are not Y. Some Y are not Z. Therefore, no Z are X.
OOA	Some X are not Y. Some Y are not Z. Therefore, all Z are X.
OIE	Some X are not Y. Some Y are Z. Therefore, no Z are X.
OIA	Some X are not Y. Some Y are Z. Therefore, all Z are X.
IOE	Some X are Y. Some Y are not Z. Therefore, no Z are X.
IOA	Some X are Y. Some Y are not Z. Therefore, all Z are X.
IIE	Some X are Y. Some Y are Z. Therefore, no Z are X.
IIA	Some X are Y. Some Y are Z. Therefore, all Z are X.
OEO	Some X are not Y. No Y are Z. Therefore, some Z are not X.

OEI	Some X are not Y. No Y are X. Therefore, some Z are X.
OAO	Some X are not Y. All Y are Z. Therefore, some Z are not X.
OAI	Some X are not Y. All Y are Z. Therefore, some Z are X.
IEO	Some X are Y. No Y are Z. Therefore, some Z are not X.
IEI	Some X are Y. No Y are Z. Therefore, some Z are X.
IAO	Some X are Y. All Y are Z. Therefore, some Z are not X.
IAI	Some X are Y. All Y are Z. Therefore, some Z are X.
OEE	Some X are not Y. No Y are Z. Therefore, no Z are X.
OEA	Some X are not Y. No Y are Z. Therefore, all Z are X.

OAE	Some X are not Y. All Y are Z. Therefore, no Z are X.
EOA	No X are Y. Some Y are not Z. Therefore, all Z are X.
EIE	No X are Y. Some Y are Z. Therefore, no Z are X.
EIA	No X are Y. Some Y are Z. Therefore, all Z are X.
AOE	All X are Y. Some Y are not Z. Therefore, no Z are X.
AOA	All X are Y. Some Y are not Z. Therefore, all Z are X.
AIE	All X are Y. Some Y are Z. Therefore, no Z are X.
AIA	All X are Y. Some Y are Z. Therefore, all Z are X.
EEO	No X are Y. No Y are Z. Therefore, some Z are not X.

EEI

No X are Y.
No Y are Z.
Therefore, some Z are X.

EAO

No X are Y.
All Y are Z.
Therefore, some Z are not X.

EAI

No X are Y.
All Y are Z.
Therefore, some Z are X.

AEO

All X are Y.
No Y are Z.
Therefore, some Z are not X.

AEI

All X are Y.
No Y are Z.
Therefore, some Z are X.

AAO

All X are Y.
All Y are Z.
Therefore, some Z are not X.

AAI

All X are Y.
All Y are Z.
Therefore, some Z are X.

EEE

Nc X are Y.
No Y are Z.
Therefore, no Z are X.

EEA

No X are Y.
No Y are Z.
Therefore, all Z are X.

EAE

No X are Y.
All Y are Z.
Therefore, no Z are X.

EAA	No X are Y. All Y are Z. Therefore, all Z are X.
AEE	All X are Y. No Y are Z. Therefore, no Z are X.
AEA	All X are Y. No Y are Z. Therefore, all Z are X.
AAE	All X are Y. All Y are Z. Therefore, no Z are X.
AAA	All X are Y. All Y are Z. Therefore, all Z are X.
OAA	Some X are not Y. All Y are Z. Therefore, all Z are X.
IEE	Some X are Y. No Y are Z. Therefore, no Z are X.
IEA	Some X are Y. No Y are Z. Therefore, all Z are X.
IAE	Some X are Y. All Y are Z. Therefore, no Z are X.

IAA	Some X are Y. All Y are Z. Therefore, all Z are X.
EOO	No X are Y. Some Y are not Z. Therefore, some Z are not X.
EOI	No X are Y. Some Y are not Z. Therefore, some Z are X.
EIO	No X are Y. Some Y are Z. Therefore, some Z are not X.
EII	No X are Y. Some Y are Z. Therefore, some Z are X.
AOO	All X are Y. Some Y are not Z. Therefore, some Z are not X.
AOI	All X are Y. Some Y are not Z. Therefore, some Z are X.
AIO	All X are Y. Some Y are Z. Therefore, some Z are not X.
AII	All X are Y. Some Y are Z. Therefore, some Z are X.
EOE	No X are Y. Some Y are not Z. Therefore, no Z are X.

APPENDIX B

Position of Each Syllogistic Mood

in Each Experimental List

Position	List I	List II	List III
1.	OIE	IEE	OII
2.	OII	OEE	IAI
3.	IEE	EEA	OOO
4.	AIE	AEE	EEA
5.	OAO	IIA	IAO
6.	IAO	OEO	AAE
7.	EOA	OOI	OIE
8.	AEO	EAE	AIE
9.	IAI	EEI	IEI
10.	OOI	OAA	EAA
11.	IEI	AAA	IEE
12.	AII	IAI	OEO
13.	IOI	III	OAA
14.	OIO	EEE	EOA
15.	EEA	IEI	AOI
16.	EIO	AII	AEO
17.	AEE	AAE	IEA
18.	AOI	OIE	OOI
19.	OOA	OOO	IOI
20.	EAO	OII	EAI
21.	OAA	OAO	EAO
22.	EEE	IEA	OOE
23.	EII	EAA	AAI
24.	OEE	EIO	IIA
25.	EOE	EOA	EII
26.	AAE	AOI	III
27.	AOO	AEO	OAO
28.	EOI	EAI	OEA
29.	AIO	EII	AIO
30.	IIA	AIO	EEE

Position	List I	List II	List III
31.	III	AEI	AEI
32.	IEA	EAO	OIA
33.	EAI	OEA	EIO
34.	OIA	EIA	AAI
35.	AEI	EOE	IOA
36.	IOE	OOE	EIA
37.	IOA	AAO	OAI
38.	OEA	EEO	EOO
39.	OAI	OOA	OIO
40.	OEI	AAI	OOA
41.	EAA	IAO	AEE
42.	EIE	EEI	AAO
43.	OEO	IOI	EIE
44.	AAI	AEA	OEE
45.	EIA	AIE	AOO
46.	EEI	AIE	AOA
47.	IEO	OIA	EEI
48.	AOE	AOO	EOI
49.	AAO	IAA	IOO
50.	EAE	IOA	IOE
51.	IIE	EOI	AEA
52.	AOA	IOE	AOE
53.	AIA	OAI	AAA
54.	OOO	IIE	OEI
55.	IAA	AOE	IEO
56.	AAA	AOA	OAE
57.	OOE	EOO	EAE
58.	EEO	OEI	AIA
59.	EOO	IEO	IIO
60.	OAE	IAE	IAA
61.	IIO	OIO	EOE
62.	IOO	IOO	IAE
63.	IAE	OAE	EEO
64.	AEA	IIO	IIE

APPENDIX C

Proportion of Acceptance Responses

for Each Syllogism in Each List

Mood	List I	List II	List III
OOO	.720	.846	.852
OOI	.680	.615	.630
OIO	.880	.808	.926
OII	.320	.654	.778
IOO	.840	.846	.778
IOI	.680	.462	.704
IIO	.800	.692	.926
III	.840	.769	.778
OOE	.120	.000	.000
OOA	.040	.038	.074
OIE	.200	.269	.111
OIA	.000	.077	.148
IOE	.040	.077	.037
IOA	.080	.115	.148
IIE	.000	.000	.000
IIA	.160	.115	.074
OEO	.640	.692	.704
OEI	.520	.346	.519
OAO	.920	.923	.852
OAI	.880	.923	.815
IEO	.680	.654	.704
IEI	.000	.192	.296
IAO	.720	.731	.815
IAI	.840	1.000	1.000
OEE	.200	.423	.370
OEA	.120	.038	.148
OAE	.000	.154	.037
OAA	.080	.115	.111
IEE	.560	.577	.556
IEA	.040	.077	.074
IAE	.000	.038	.000
IAA	.200	.192	.148

Mood	List I	List II	List III
EOO	.680	.654	.630
EOI	.400	.346	.296
EIO	.760	.654	.556
EII	.080	.154	.148
AOO	.880	.846	.778
AOI	.840	.731	.815
AIO	.720	.731	.852
AII	.880	.962	.963
EOE	.240	.577	.370
EOA	.120	.154	.111
EIE	.400	.538	.704
EIA	.000	.000	.037
AOE	.080	.038	.185
AOA	.040	.000	.074
AIE	.120	.038	.037
AIA	.160	.231	.185
EEO	.440	.462	.370
EEI	.240	.115	.407
EAO	.680	.615	.630
EAI	.120	.077	.074
AEO	.640	.500	.556
AEI	.040	.038	.037
AAO	.040	.115	.222
AAI	.840	.654	.630
EEE	.560	.615	.556
EEA	.120	.115	.148
EAE	.720	.885	.852
EAA	.040	.038	.000
AEE	.960	.885	.815
AEA	.120	.038	.074
AAE	.080	.000	.074
AAA	.840	.846	.815